In [141]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import KFold
import seaborn as sas
import matplotlib.pyplot as plt
import sklearn
from sklearn.model_selection import train_test_split
from sklearn import datasets, linear_model
from sklearn.preprocessing import StandardScaler
from scipy.cluster.hierarchy import linkage,fcluster
from sklearn import metrics
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
import seaborn as sns
from sklearn.linear_model import LinearRegression
import statsmodels.formula.api as smf
from sklearn.cluster import KMeans, DBSCAN,AgglomerativeClustering
from sklearn import metrics
import plotly.figure_factory as ff
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import OneHotEncoder
from sklearn.compose import ColumnTransformer
!pip install imblearn
from imblearn.over_sampling import SMOTE
from imblearn.under_sampling import NearMiss
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
```

```
Requirement already satisfied: imblearn in /opt/anaconda3/lib/python3.
7/site-packages (0.0)
Requirement already satisfied: imbalanced-learn in /opt/anaconda3/lib/p
ython3.7/site-packages (from imblearn) (0.5.0)
Requirement already satisfied: joblib>=0.11 in /opt/anaconda3/lib/pytho
n3.7/site-packages (from imbalanced-learn->imblearn) (0.13.2)
Requirement already satisfied: numpy>=1.11 in /opt/anaconda3/lib/python
3.7/site-packages (from imbalanced-learn->imblearn) (1.17.2)
Requirement already satisfied: scipy>=0.17 in /opt/anaconda3/lib/python
3.7/site-packages (from imbalanced-learn->imblearn) (1.3.1)
Requirement already satisfied: scikit-learn>=0.21 in /opt/anaconda3/li
b/python3.7/site-packages (from imbalanced-learn->imblearn) (0.21.3)
```

In [142]:
```
#from google.colab import drive
#drive.mount('/content/drive')
```

In [143]:
```
# Import the CSV file
df = pd.read_csv("Merge_1.csv")
df.head()
```

Out[143]:

	District	index	Case Number	Date	Block	IUCR	Primary Type	Description	Loc Descri
0	4	2	JB528220	11/24/2018	095XX S STONY ISLAND AVE	0261	CRIM SEXUAL ASSAULT	AGGRAVATED: HANDGUN	A
1	22	3	JB495848	08/27/2018	092XX S UNION AVE	1120	DECEPTIVE PRACTICE	FORGERY	RESID
2	7	5	JB505888	09/27/2018	068XX S PERRY AVE	1020	ARSON	BY FIRE	VEH COMMER
3	24	6	JB472665	10/12/2018	061XX N BROADWAY	0890	THEFT	FROM BUILDING	COMMER / BUSI OI
4	8	9	JB241744	04/27/2018	070XX S CALIFORNIA AVE	1562	SEX OFFENSE	AGG CRIMINAL SEXUAL ABUSE	APARTI

5 rows × 30 columns

In [144]:
```
df['ArrestLabel']=df['Arrest']
df.head()
```

Out[144]:

	District	index	Case Number	Date	Block	IUCR	Primary Type	Description	Loc Descri
0	4	2	JB528220	11/24/2018	095XX S STONY ISLAND AVE	0261	CRIM SEXUAL ASSAULT	AGGRAVATED: HANDGUN	A
1	22	3	JB495848	08/27/2018	092XX S UNION AVE	1120	DECEPTIVE PRACTICE	FORGERY	RESID
2	7	5	JB505888	09/27/2018	068XX S PERRY AVE	1020	ARSON	BY FIRE	VEH COMMER
3	24	6	JB472665	10/12/2018	061XX N BROADWAY	0890	THEFT	FROM BUILDING	COMMER / BUSI OI
4	8	9	JB241744	04/27/2018	070XX S CALIFORNIA AVE	1562	SEX OFFENSE	AGG CRIMINAL SEXUAL ABUSE	APARTI

5 rows × 31 columns

In [145]:
```
#Dropping irrelevant columns
df=df.drop(columns=['Arrest'])
```

In [146]:
```
df.rename(columns={'ArrestLabel':'Arrest'},inplace=True)
df.head()
```

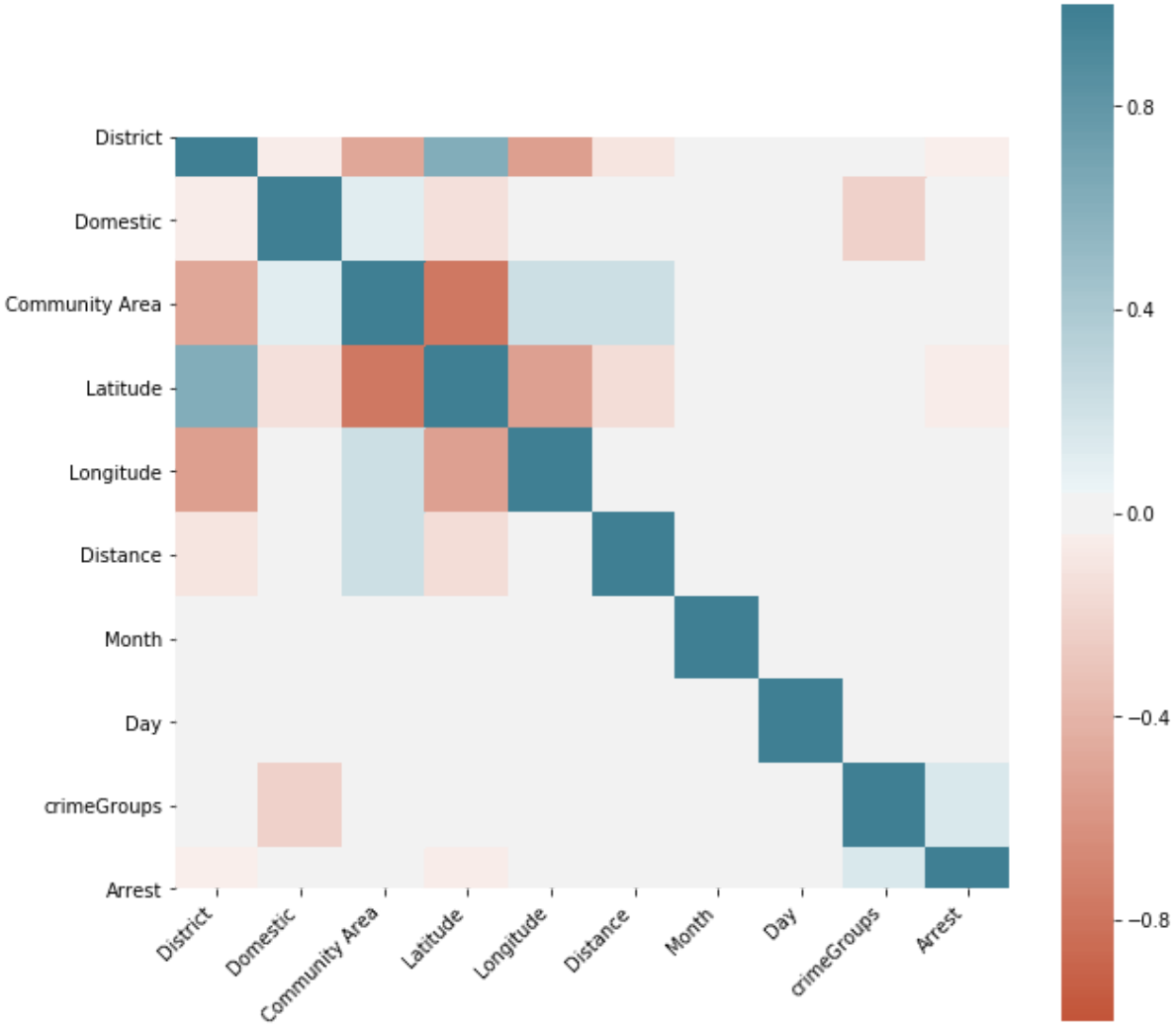
Out[146]:

	District	index	Case Number	Date	Block	IUCR	Primary Type	Description	Loc Descri
0	4	2	JB528220	11/24/2018	095XX S STONY ISLAND AVE	0261	CRIM SEXUAL ASSAULT	AGGRAVATED: HANDGUN	A
1	22	3	JB495848	08/27/2018	092XX S UNION AVE	1120	DECEPTIVE PRACTICE	FORGERY	RESID
2	7	5	JB505888	09/27/2018	068XX S PERRY AVE	1020	ARSON	BY FIRE	VEH COMMER
3	24	6	JB472665	10/12/2018	061XX N BROADWAY	0890	THEFT	FROM BUILDING	COMMER / BUSI OI
4	8	9	JB241744	04/27/2018	070XX S CALIFORNIA AVE	1562	SEX OFFENSE	AGG CRIMINAL SEXUAL ABUSE	APARTI

5 rows × 30 columns

In [147]:
```
#df=df.drop(columns=['IUCR','Beat','Ward','X Coordinate','Y Coordinat
e','Latitude','Longitude','p_x','p_y','p_latitude','p_longitude','Case N
umber','Block','FBI Code','Date','p_dname','Time'])
#For Crime Group
df_cgrp=df
df_cgrp=df_cgrp.drop(columns=['index','Beat','Ward','X Coordinate','Y Co
ordinate','p_x','p_y','p_latitude','p_longitude','Case Number','Block',
'FBI Code','Date','p_dname','Time'])
#For Arrest
df=df.drop(columns=['index','IUCR','Beat','Ward','X Coordinate','Y Coord
inate','p_x','p_y','p_latitude','p_longitude','Case Number','Block','FBI
Code','Date','p_dname','Time','Season'])
```

In [148]:
```
corr = df.corr()
fig, ax = plt.subplots(figsize=(10,10))
ax = sns.heatmap(
    corr,
    vmin=-1, vmax=1, center=0,
    cmap=sns.diverging_palette(20, 220, n=200),
    square=True
)
ax.set_xticklabels(
    ax.get_xticklabels(),
    rotation=45,
    horizontalalignment='right'
);
```



In [149]:
```
#Predicting Arrest
df=df.drop(columns=['Day','Month'])
#making dummy variables out of the object variables
df_dum= pd.get_dummies(df)
df_dum.head()
```

Out[149]:

	District	Domestic	Community Area	Latitude	Longitude	Distance	crimeGroups	Arrest	Typ
0	4	0	51.0	41.721844	-87.585072	6822.245420	1	1	
1	22	0	73.0	41.726124	-87.640913	14717.784521	3	1	
2	7	0	69.0	41.770428	-87.628300	9500.832396	2	1	
3	24	0	77.0	41.992509	-87.660344	3987.355350	2	1	
4	8	1	66.0	41.765884	-87.693061	6432.894093	1	0	

5 rows × 481 columns

In [150]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 485344 entries, 0 to 485343
Data columns (total 11 columns):
District                485344 non-null int64
Primary Type            485344 non-null object
Description             485344 non-null object
Location Description    485344 non-null object
Domestic                485344 non-null int64
Community Area          485344 non-null float64
Latitude                485344 non-null float64
Longitude               485344 non-null float64
Distance                485344 non-null float64
crimeGroups             485344 non-null int64
Arrest                  485344 non-null int64
dtypes: float64(4), int64(4), object(3)
memory usage: 40.7+ MB
```

In [216]:
```
X = df_dum.drop(columns=["crimeGroups","Arrest"])
y = df_dum[["crimeGroups","Arrest"]]
print(X.shape, y.shape)
```

```
(485344, 479) (485344, 2)
```

In [217]:
```
y.head()
```

Out[217]:

	crimeGroups	Arrest
0	1	1
1	3	1
2	2	1
3	2	1
4	1	0

In [218]:
```
X.head()
```

Out[218]:

	District	Domestic	Community Area	Latitude	Longitude	Distance	Primary Type_ARSON	Prir Type_ASSA
0	4	0	51.0	41.721844	-87.585072	6822.245420	0	
1	22	0	73.0	41.726124	-87.640913	14717.784521	0	
2	7	0	69.0	41.770428	-87.628300	9500.832396	1	
3	24	0	77.0	41.992509	-87.660344	3987.355350	0	
4	8	1	66.0	41.765884	-87.693061	6432.894093	0	

5 rows × 479 columns

In [219]:
```
#Dividing the data into Train and Test set
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size = 0.2
, random_state=0)
```

In [220]:
```
print(X_train.shape)
print(y_train.shape)
```

```
(388275, 479)
(388275, 2)
```

In [221]:
```
print(y_train.head())
```

```
        crimeGroups  Arrest
47047             3       0
218820            3       0
152182            1       0
124793            2       0
144937            1       0
```

In [222]:
```
print(X_test.shape)
print(y_test.shape)
```

```
(97069, 479)
(97069, 2)
```

In [223]:
```
#Splitting the Training data into Train and Validation set
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test
_size=0.2, random_state=1)
```

In [224]:
```
print(X_val.shape)
print(y_val.shape)
```

```
(77655, 479)
(77655, 2)
```

In [237]:
```
# Standardize train and Validation set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train)
x_train_scaled = scaler.transform(X_train)
x_val_scaled = scaler.transform(X_val)
x_train_scaled
```

Out[237]:
```
array([[0.57564331, 0.        , 2.14997018, ..., 0.        , 0.
,
        0.        ],
       [2.5903949 , 0.        , 0.37390786, ..., 0.        , 0.
,
        0.        ],
       [0.43173248, 0.        , 2.00975473, ..., 0.        , 0.
,
        0.        ],
       ...,
       [1.29519745, 0.        , 2.75757045, ..., 0.        , 0.
,
        0.        ],
       [3.45385987, 0.        , 0.09347696, ..., 0.        , 0.
,
        0.        ],
       [0.86346497, 0.        , 3.31843223, ..., 0.        , 0.
,
        0.        ]])
```

In [241]:
```
#Using Logistic Regression
classifier = LogisticRegression(solver="lbfgs",max_iter=1000)
classifier
```

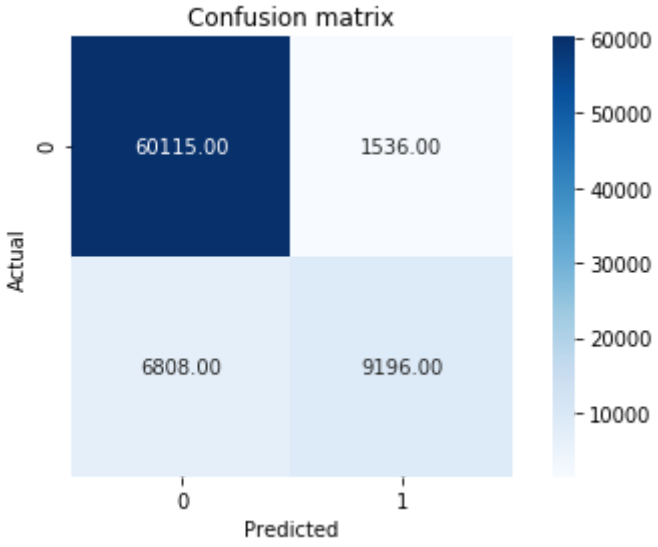
Out[241]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [242]:
```
#fit (train) model with training data for Arrests
classifier.fit(x_train_scaled, y_train['Arrest'])
```

Out[242]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [243]:
```
predictions = classifier.predict(x_val_scaled)
```

In [244]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],predictions)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".2f", square
= True, cmap = plt.cm.Blues)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [245]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'],predictions)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'],predictions)
recall = metrics.recall_score(y_val['Arrest'],predictions)
F1_score = metrics.f1_score(y_val['Arrest'],predictions,average='weighte
d')
print([accuracy, error, precision, recall,F1_score])
```

```
[0.8925503831047582, 0.1074496168952418, 0.8568766306373462, 0.57460634
84128968, 0.8841594443513132]
```

In [246]:
```
# Standardize train and Test set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train)
x_train_scaled = scaler.transform(X_train)
x_test_scaled = scaler.transform(X_test)
```

In [247]:
```
#Final Model wiith Test Set
#Using Logistic Regression
classifier = LogisticRegression(solver="lbfgs",max_iter=1000)
classifier
```

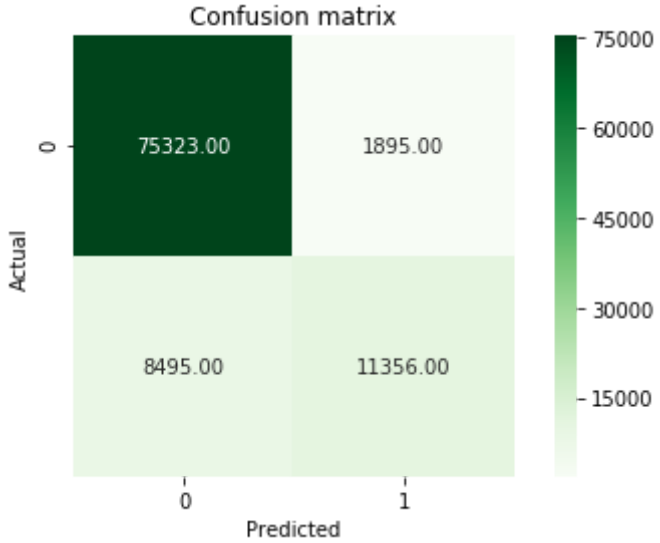
Out[247]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [248]:
```
#fit (train) model with training data for Arrests
classifier.fit(x_train_scaled, y_train['Arrest'])
```

Out[248]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [249]:
```
predictions = classifier.predict(x_test_scaled)
```

In [250]:
```
conf_matrix = metrics.confusion_matrix(y_test['Arrest'],predictions)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".2f", square
= True, cmap = plt.cm.Greens)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



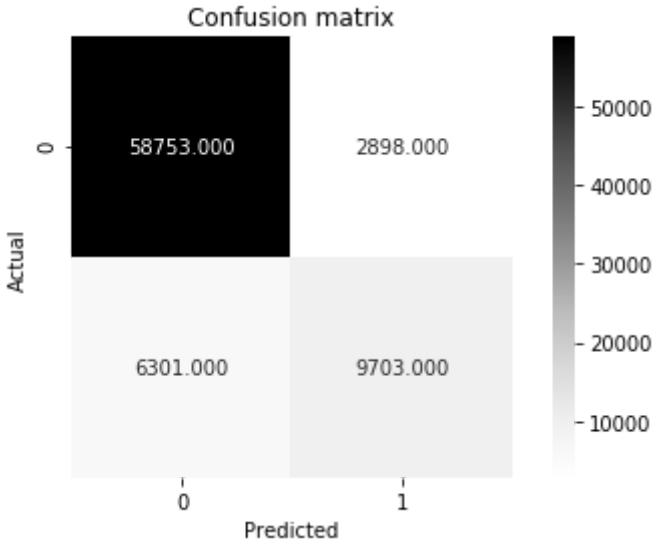
In [251]:
```
accuracy = metrics.accuracy_score(y_test['Arrest'],predictions)
error = 1 - accuracy
precision = metrics.precision_score(y_test['Arrest'],predictions)
recall = metrics.recall_score(y_test['Arrest'],predictions)
F1_score = metrics.f1_score(y_test['Arrest'],predictions,average='weighted')
print([accuracy, error, precision, recall,F1_score])
```

```
[0.8929627378462743, 0.10703726215372567, 0.8569919251377255, 0.5720618608634326, 0.8844854349317147]
```

In [167]:
```
#Using Random Forest to build the model
rf = RandomForestClassifier(n_estimators=100)
rf = rf.fit(x_train_scaled, y_train['Arrest'])
rf.score(x_val_scaled, y_val['Arrest'])
```

Out[167]:
```
0.8815401455154208
```

In [168]:
```
y_pred = rf.predict(x_val_scaled)
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square = True, cmap = plt.cm.Greys)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [169]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall,F1_score])
```

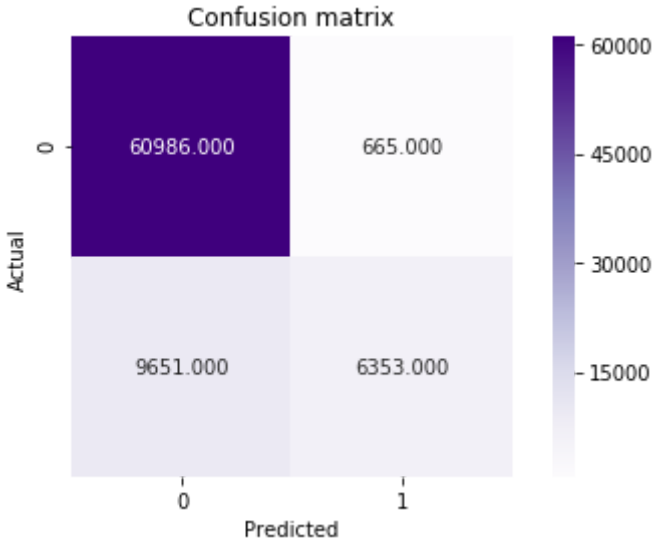
```
[0.8815401455154208, 0.11845985448457919, 0.7700182525196413, 0.6062859285178706, 0.8760846217713733]
```

In [170]:
```
#-----------------Naive Bayes Classifier using different attributes ----
----------------
classifier = GaussianNB()
classifier.fit(x_train_scaled,y_train['Arrest'])
```

Out[170]:
```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [171]:
```
y_pred = classifier.predict(x_val_scaled)
```

In [172]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'], y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.Purples)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [173]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.8671560105595261, 0.13284398944047393, 0.9052436591621544, 0.3969632
591852037, 0.8457419082834318]
```

In [252]:
```
#Using SMOTE to oversample the minority class data
smt = SMOTE()
X_train_s, y_train_s = smt.fit_sample(X_train, y_train['Arrest'])
```

In [253]:
```
np.bincount(y_train_s)
```

Out[253]:
```
array([246390, 246390])
```

In [254]:
```
# Standardize train and Validation set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train_s)
x_train_scaled = scaler.transform(X_train_s)
x_val_scaled = scaler.transform(X_val)
x_train_scaled
```

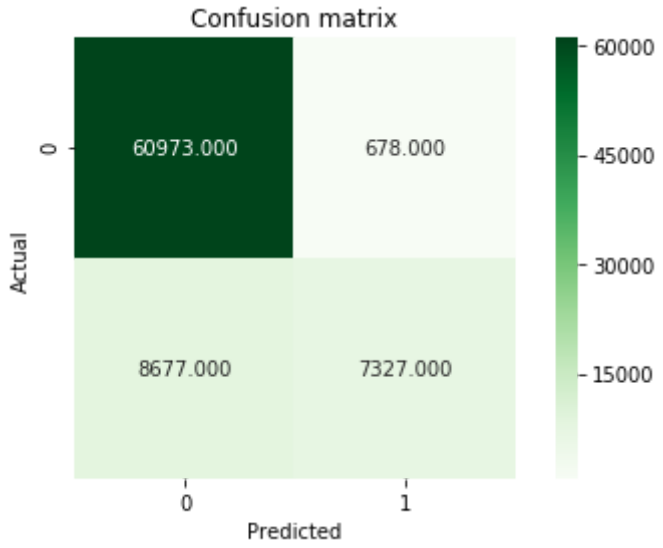
Out[254]:
```
array([[0.59691002, 0.        , 2.19317813, ..., 0.        , 0.
,
        0.        ],
       [2.6860951 , 0.        , 0.38142228, ..., 0.        , 0.
,
        0.        ],
       [0.44768252, 0.        , 2.05014477, ..., 0.        , 0.
,
        0.        ],
       ...,
       [1.04459254, 0.        , 3.24208941, ..., 0.        , 0.
,
        0.        ],
       [2.6860951 , 0.        , 0.38142228, ..., 0.        , 0.
,
        0.        ],
       [2.85930848, 0.56267244, 0.31685754, ..., 0.        , 0.
,
        0.        ]])
```

In [201]:
```
#-----------------Naive Bayes Classifier after SMOTE ------------------
-
classifier = GaussianNB()
classifier.fit(x_train_scaled,y_train_s)
```

Out[201]:
```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [178]:
```
y_pred = classifier.predict(x_val_scaled)
```

In [179]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'], y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.Greens)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [180]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.8795312600605241, 0.12046873993947593, 0.9153029356652093, 0.4578230
4423894027, 0.8631327154922487]
```

In [255]:
```
#Using Logistic Regression for SMOTE
classifier = LogisticRegression(solver="lbfgs",max_iter=1000)
classifier
```

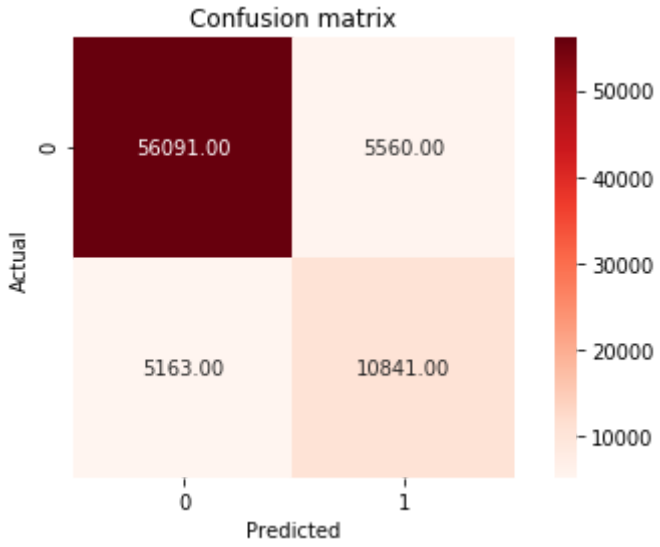
Out[255]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [256]:
```
#fit (train) model with training data for Arrests
classifier.fit(x_train_scaled, y_train_s)
```

Out[256]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [257]:
```
predictions = classifier.predict(x_val_scaled)
```

In [259]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],predictions)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".2f", square
= True, cmap = plt.cm.Reds)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



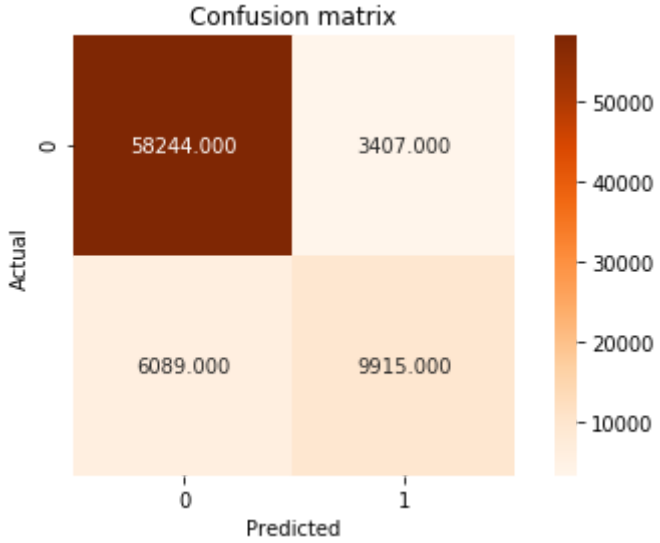
In [260]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'],predictions)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'],predictions)
recall = metrics.recall_score(y_val['Arrest'],predictions)
F1_score = metrics.f1_score(y_val['Arrest'],predictions,average='weighte
d')
print([accuracy, error, precision, recall,F1_score])
```

```
[0.8619148799175842, 0.1380851200824158, 0.6609962807145906, 0.67739315
17120719, 0.8625377169048841]
```

In [181]:
```
#Using Random Forest to build the model after SMOTE
rf = RandomForestClassifier(n_estimators=100)
rf = rf.fit(x_train_scaled, y_train_s)
rf.score(x_val_scaled, y_val['Arrest'])
```

Out[181]:
```
0.8777155366685983
```

In [182]:
```
y_pred = rf.predict(x_val_scaled)
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.Oranges)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [183]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.8777155366685983, 0.12228446333140175, 0.7442576189761297, 0.6195326
168457885, 0.873425414683152]
```

In [261]:
```
#Undersampling majority class
nr = NearMiss()
X_train_m, y_train_m = nr.fit_sample(X_train, y_train['Arrest'])
```

In [262]:
```
np.bincount(y_train_m)
```

Out[262]:
```
array([64230, 64230])
```

In [263]:
```
# Standardize train and Validation set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train_m)
x_train_scaled = scaler.transform(X_train_m)
x_val_scaled = scaler.transform(X_val)
x_train_scaled
```

Out[263]:
```
array([[2.90930747, 0.        , 0.29116173, ..., 0.        , 0.
,
        0.        ],
       [2.75618602, 0.        , 0.38821564, ..., 0.        , 0.
,
        0.        ],
       [2.75618602, 0.        , 0.38821564, ..., 0.        , 0.
,
        0.        ],
       ...,
       [3.82803614, 0.        , 1.21317389, ..., 0.        , 0.
,
        0.        ],
       [1.83745735, 0.        , 1.35875475, ..., 0.        , 0.
,
        0.        ],
       [1.37809301, 0.        , 2.86309037, ..., 0.        , 0.
,
        0.        ]])
```

In [264]:
```
#Using Logistic Regression for near miss
classifier = LogisticRegression(solver="lbfgs",max_iter=1000)
classifier
```

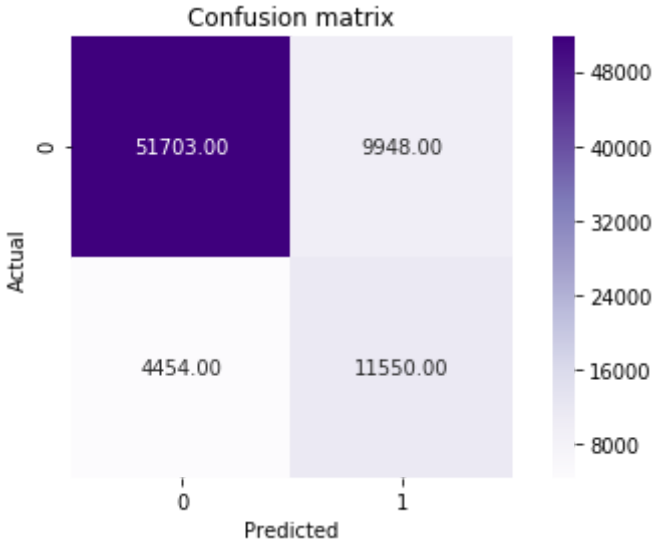
Out[264]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [265]:
```
#fit (train) model with training data for Arrests
classifier.fit(x_train_scaled, y_train_m)
```

Out[265]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=
True,
                   intercept_scaling=1, l1_ratio=None, max_iter=1000,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbo
se=0,
                   warm_start=False)
```

In [266]:
```
predictions = classifier.predict(x_val_scaled)
```

In [267]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],predictions)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".2f", square
= True, cmap = plt.cm.Purples)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [268]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'],predictions)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'],predictions)
recall = metrics.recall_score(y_val['Arrest'],predictions)
F1_score = metrics.f1_score(y_val['Arrest'],predictions,average='weighte
d')
print([accuracy, error, precision, recall,F1_score])
```

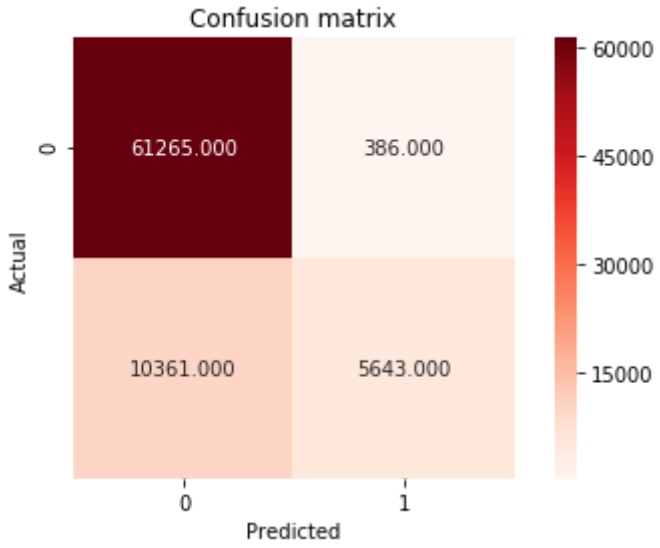
```
[0.8145386646062713, 0.18546133539372867, 0.537259279933017, 0.72169457
6355911, 0.8237990875820814]
```

In [187]:
```
#-----------------Naive Bayes Classifier after near Miss ---------------
-----
classifier = GaussianNB()
classifier.fit(x_train_scaled,y_train_m)
```

Out[187]:
```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [188]:
```
y_pred = classifier.predict(x_val_scaled)
```

In [189]:
```
conf_matrix = metrics.confusion_matrix(y_val['Arrest'], y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.Reds)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



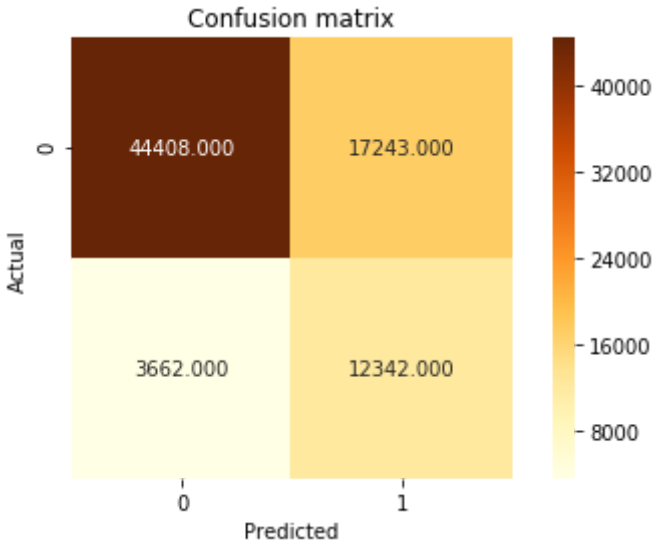
In [190]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.8616058206168309, 0.1383941793831691, 0.9359761154420302, 0.35259935
01624594, 0.8354572178815222]
```

In [191]:
```
#Using Random Forest to build the model after Near Miss
rf = RandomForestClassifier(n_estimators=100)
rf = rf.fit(x_train_scaled, y_train_m)
rf.score(x_val_scaled, y_val['Arrest'])
```

Out[191]:
```
0.7307964715729831
```

In [192]:
```
y_pred = rf.predict(x_val_scaled)
conf_matrix = metrics.confusion_matrix(y_val['Arrest'],y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.YlOrBr)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



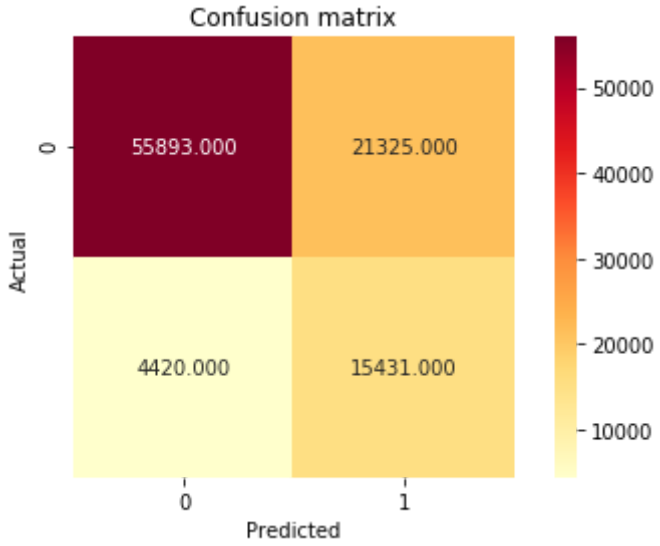
In [193]:
```
accuracy = metrics.accuracy_score(y_val['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_val['Arrest'], y_pred)
recall = metrics.recall_score(y_val['Arrest'], y_pred)
F1_score = metrics.f1_score(y_val['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.7307964715729831, 0.2692035284270169, 0.41717086361331757, 0.7711822
044488877, 0.7542337652638942]
```

In [194]:
```
# Predicting for test set using Logistic Regression after near Miss
# Standardize train and Validation set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train_m)
x_train_scaled = scaler.transform(X_train_m)
x_test_scaled = scaler.transform(X_test)
x_train_scaled
rf = RandomForestClassifier(n_estimators=100)
rf = rf.fit(x_train_scaled, y_train_m)
rf.score(x_test_scaled, y_test['Arrest'])
```

Out[194]: 0.7347762931522938

In [195]:
```
y_pred = rf.predict(x_test_scaled)
conf_matrix = metrics.confusion_matrix(y_test['Arrest'],y_pred)
sns.heatmap(conf_matrix,yticklabels=2, annot = True, fmt = ".3f", square
= True, cmap = plt.cm.YlOrRd)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [101]:
```
accuracy = metrics.accuracy_score(y_test['Arrest'], y_pred)
error = 1 - accuracy
precision = metrics.precision_score(y_test['Arrest'], y_pred)
recall = metrics.recall_score(y_test['Arrest'], y_pred)
F1_score = metrics.f1_score(y_test['Arrest'], y_pred,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.7344878385478371, 0.26551216145216294, 0.41961667933543273, 0.778650
9495743288]
```

In [269]:
```
df_cgrp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 485344 entries, 0 to 485343
Data columns (total 15 columns):
District                485344 non-null int64
IUCR                    485344 non-null object
Primary Type            485344 non-null object
Description             485344 non-null object
Location Description    485344 non-null object
Domestic                485344 non-null int64
Community Area          485344 non-null float64
Latitude                485344 non-null float64
Longitude               485344 non-null float64
Distance                485344 non-null float64
Month                   485344 non-null int64
Day                     485344 non-null int64
Season                  485344 non-null object
crimeGroups             485344 non-null int64
Arrest                  485344 non-null int64
dtypes: float64(4), int64(6), object(5)
memory usage: 55.5+ MB
```

In [270]:
```
#------------------------Predicting Crime Group-------------------------
-------
#Predicting Arrest
df_cgrp=df_cgrp.drop(columns=['Primary Type','Day','Month'])
#making dummy variables out of the object variables
df_cgrp_dum= pd.get_dummies(df_cgrp)
df_cgrp_dum.head()
```

Out[270]:

	District	Domestic	Community Area	Latitude	Longitude	Distance	crimeGroups	Arrest	IUC
0	4	0	51.0	41.721844	-87.585072	6822.245420	1	1	
1	22	0	73.0	41.726124	-87.640913	14717.784521	3	1	
2	7	0	69.0	41.770428	-87.628300	9500.832396	2	1	
3	24	0	77.0	41.992509	-87.660344	3987.355350	2	1	
4	8	1	66.0	41.765884	-87.693061	6432.894093	1	0	

5 rows × 871 columns

In [271]:
```
X_cgrp = df_cgrp_dum.drop(columns=["crimeGroups","Arrest"])
y_cgrp = df_cgrp_dum[["crimeGroups"]]
print(X_cgrp.shape, y_cgrp.shape)
```

```
(485344, 869) (485344, 1)
```

In [272]:
```
#Dividing the data into Train and Test set
X_train_c, X_test_c, y_train_c, y_test_c = train_test_split(X_cgrp,y_cgr
p, test_size = 0.2, random_state=0)
```

In [273]:
```
print(X_train_c.shape)
print(y_train_c.shape)
```

```
(388275, 869)
(388275, 1)
```

In [274]:
```
print(X_test_c.shape)
print(y_test_c.shape)
```

```
(97069, 869)
(97069, 1)
```

In [275]:
```
#Splitting the Training data into Train and Validation set
X_train_c, X_val_c, y_train_c, y_val_c = train_test_split(X_train_c, y_t
rain_c, test_size=0.2, random_state=1)
```

In [276]:
```
print(X_train_c.shape)
print(y_train_c.shape)
```

```
(310620, 869)
(310620, 1)
```

In [277]:
```
print(X_val_c.shape)
print(y_val_c.shape)
```

```
(77655, 869)
(77655, 1)
```

In [278]:
```
# Standardize train and Validation set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train_c)
x_train_scaled = scaler.transform(X_train_c)
x_val_scaled = scaler.transform(X_val_c)
x_train_scaled
```

Out[278]:
```
array([[0.57564331, 0.        , 2.14997018, ..., 0.        , 2.1849634
,
        0.        ],
       [2.5903949 , 0.        , 0.37390786, ..., 0.        , 0.
,
        0.        ],
       [0.43173248, 0.        , 2.00975473, ..., 0.        , 2.1849634
,
        0.        ],
       ...,
       [1.29519745, 0.        , 2.75757045, ..., 0.        , 0.
,
        0.        ],
       [3.45385987, 0.        , 0.09347696, ..., 2.25695919, 0.
,
        0.        ],
       [0.86346497, 0.        , 3.31843223, ..., 0.        , 2.1849634
,
        0.        ]])
```

In [279]:
```
np.squeeze(y_train_c).shape
```

Out[279]:
```
(310620,)
```

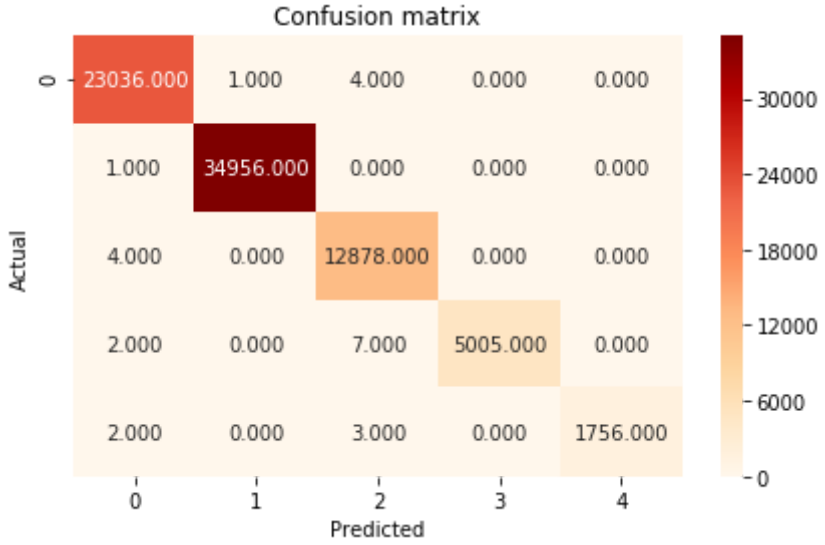
In [280]:
```
rf = RandomForestClassifier(n_estimators=100)
rf = rf.fit(x_train_scaled, np.squeeze(y_train_c))
rf.score(x_val_scaled, y_val_c)
```

Out[280]:
```
0.9996909406992467
```

In [281]:
```
y_pred_c = rf.predict(x_val_scaled)
print(f"First 10 Predictions:   {y_pred_c[:10]}")
print(f"First 10 Actual labels: {y_val_c[:10]}")
```

```
First 10 Predictions:   [4 1 1 2 2 3 1 3 1 3]
First 10 Actual labels:         crimeGroups
430036            4
263255            1
395129            1
180130            2
181342            2
410194            3
129723            1
28018             3
150122            1
318693            3
```

In [282]:
```
y_pred = rf.predict(x_val_scaled)
conf_matrix = metrics.confusion_matrix(y_val_c,y_pred_c)
sns.heatmap(conf_matrix,yticklabels=5, annot = True, fmt = ".3f", square
= False, cmap = plt.cm.OrRd)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [116]:
```
accuracy = metrics.accuracy_score(y_val_c, y_pred_c)
error = 1 - accuracy
precision = metrics.precision_score(y_val_c, y_pred_c,average='weighted'
)
recall = metrics.recall_score(y_val_c, y_pred_c,average='weighted')
F1_score = metrics.f1_score(y_val_c, y_pred_c,average='weighted')
print([accuracy, error, precision, recall, F1_score])
```

```
[0.9996007984031936, 0.0003992015968063978, 0.999600976573303, 0.999600
7984031936]
```

In [117]:
```
# Random Forest Model fit on test set
#Standardize train and Test set
scaler = StandardScaler(with_mean=False)
scaler.fit(X_train_c)
x_train_scaled = scaler.transform(X_train_c)
x_test_scaled = scaler.transform(X_test_c)
x_train_scaled
```

Out[117]:
```
array([[0.57564331, 0.        , 2.14997018, ..., 0.        , 2.1849634
,
        0.        ],
       [2.5903949 , 0.        , 0.37390786, ..., 0.        , 0.
,
        0.        ],
       [0.43173248, 0.        , 2.00975473, ..., 0.        , 2.1849634
,
        0.        ],
       ...,
       [1.29519745, 0.        , 2.75757045, ..., 0.        , 0.
,
        0.        ],
       [3.45385987, 0.        , 0.09347696, ..., 2.25695919, 0.
,
        0.        ],
       [0.86346497, 0.        , 3.31843223, ..., 0.        , 2.1849634
,
        0.        ]])
```

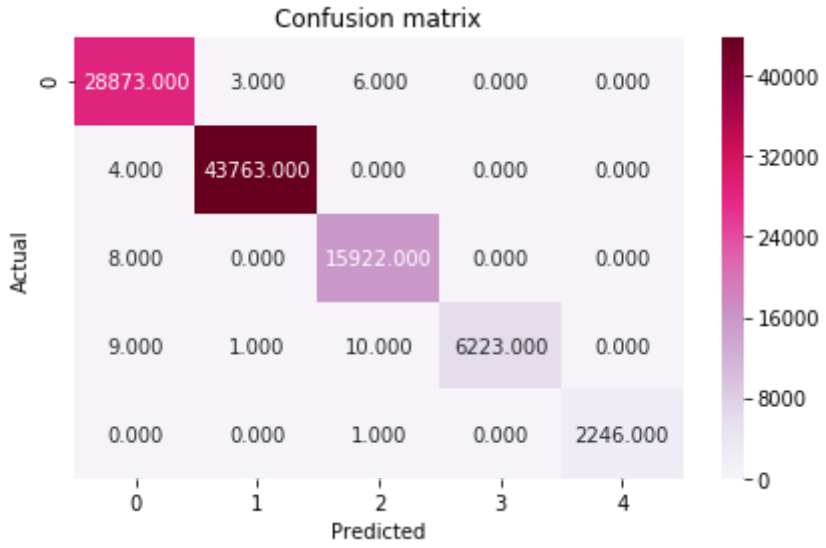
In [118]:
```
rf.score(x_test_scaled, y_test_c)
```

Out[118]:
```
0.9995673180933151
```

In [119]:
```
y_pred_c = rf.predict(x_test_scaled)
print(f"First 10 Predictions:   {y_pred_c[:10]}")
print(f"First 10 Actual labels: {y_test_c[:10]}")
```

```
First 10 Predictions:   [2 2 2 2 2 1 3 2 2 2]
First 10 Actual labels:         crimeGroups
1869                 2
334031               2
421823               2
435435               2
425940               2
431978               1
195397               3
248713               2
299268               2
305936               2
```

In [120]:
```
conf_matrix = metrics.confusion_matrix(y_test_c,y_pred_c)
sns.heatmap(conf_matrix,yticklabels=5, annot = True, fmt = ".3f", square
= False, cmap = plt.cm.PuRd)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [121]:
```
accuracy = metrics.accuracy_score(y_test_c, y_pred_c)
error = 1 - accuracy
precision = metrics.precision_score(y_test_c, y_pred_c,average='weighte
d')
recall = metrics.recall_score(y_test_c, y_pred_c,average='weighted')
F1_score = metrics.f1_score(y_test_c, y_pred_c,average='weighted')
print([accuracy, error, precision, recall,F1_score])
```

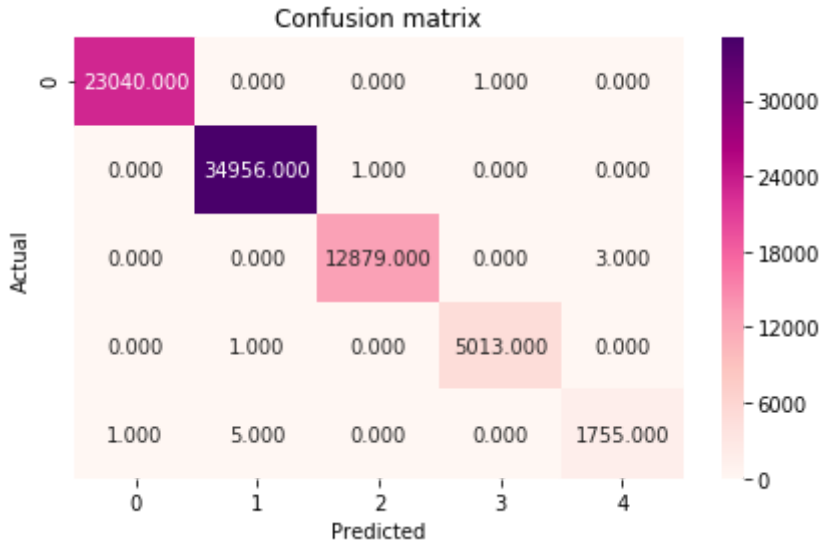
```
[0.9995673180933151, 0.0004326819066848415, 0.9995675068315367, 0.9995
673180933151]
```

In [122]:
```
#-----------------Naive Bayes Classifier for Crime group ---------------
-----
classifier = GaussianNB()
classifier.fit(x_train_scaled,np.squeeze(y_train_c))
```

Out[122]:
```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [123]:
```
y_pred_c = classifier.predict(x_val_scaled)
```

In [124]:
```
conf_matrix = metrics.confusion_matrix(y_val_c, y_pred_c)
sns.heatmap(conf_matrix,yticklabels=5, annot = True, fmt = ".3f", square
= False, cmap = plt.cm.RdPu)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```

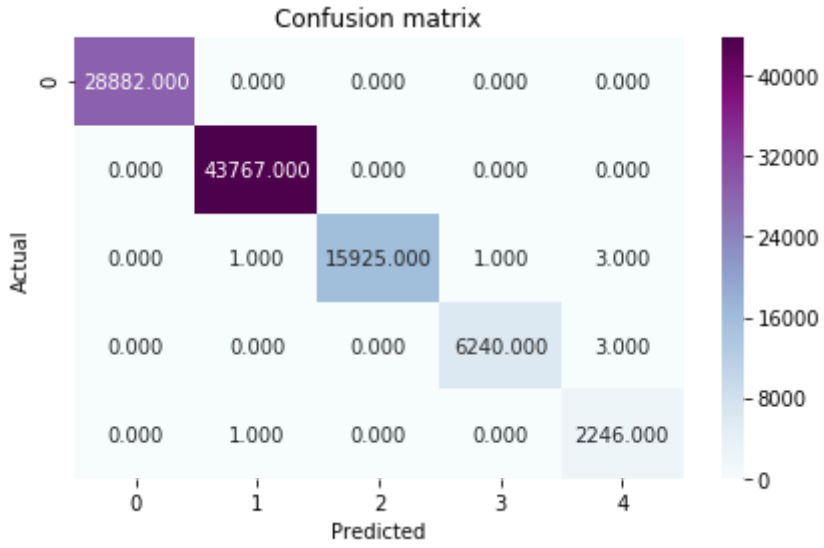


In [125]:
```
accuracy = metrics.accuracy_score(y_val_c, y_pred_c)
error = 1 - accuracy
precision = metrics.precision_score(y_val_c, y_pred_c,average='weighted'
)
recall = metrics.recall_score(y_val_c, y_pred_c,average='weighted')
F1_score = metrics.f1_score(y_val_c, y_pred_c,average='weighted')
print([accuracy, error, precision, recall,F1_score])
```

```
[0.9998454703496233, 0.00015452965037665578, 0.9998454134742264, 0.9998
454703496233]
```

In [126]:
```
#--------Predicting for Test set-----------------------------
y_pred_c = classifier.predict(x_test_scaled)
```

In [127]:
```
conf_matrix = metrics.confusion_matrix(y_test_c,y_pred_c)
sns.heatmap(conf_matrix,yticklabels=5, annot = True, fmt = ".3f", square
= False, cmap = plt.cm.BuPu)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Confusion matrix')
plt.tight_layout()
```



In [164]:
```
accuracy = metrics.accuracy_score(y_test_c, y_pred_c)
error = 1 - accuracy
precision = metrics.precision_score(y_test_c, y_pred_c,average='weighte
d')
recall = metrics.recall_score(y_test_c, y_pred_c,average='weighted')
F1_score = metrics.f1_score(y_test_c, y_pred_c,average='weighted')
print([accuracy, error, precision, recall,F1_score])
```

```
[0.9999072824485675, 9.271755143247518e-05, 0.9999074173260198, 0.99990
72824485675, 0.9999073154126222]
```

In [ ]:
```

```

In [129]:
```
#-----------------------------------------Clustering-----------------
-----------------------#
```

In [130]:
```
df_cgrp['crimeGroups'].value_counts()
```

Out[130]:
```
2    218069
1    144223
3     80236
4     31506
5     11310
Name: crimeGroups, dtype: int64
```

In [131]:
```
##X = df_dum.drop(columns=["crimeGroups","Arrest"])
#y = df_dum[["crimeGroups","Arrest"]]
print(X.shape, y.shape)
X_cgrp = df_cgrp_dum.drop(columns=["crimeGroups","Arrest","Distance","La
titude","Longitude","Season_Spring","Season_Autumn","Season_Summer","Sea
son_Winter"])
y_cgrp = df_cgrp_dum[["crimeGroups"]]
print(X_cgrp.shape, y_cgrp.shape)
```

```
(485344, 479) (485344, 2)
(485344, 862) (485344, 1)
```

In [132]:
```
print(X_cgrp.shape, y_cgrp.shape)
```

```
(485344, 862) (485344, 1)
```

In [133]:
```
X_cgrp.head()
```

Out[133]:

	District	Domestic	Community Area	IUCR_0110	IUCR_0142	IUCR_0261	IUCR_0262	IUCR_0263	IU
0	4	0	51.0	0	0	1	0	0	
1	22	0	73.0	0	0	0	0	0	
2	7	0	69.0	0	0	0	0	0	
3	24	0	77.0	0	0	0	0	0	
4	8	1	66.0	0	0	0	0	0	

5 rows × 862 columns

In [134]:
```
scaler = StandardScaler(with_mean=False)
scaler.fit(X_cgrp)
x_scaled = scaler.transform(X_cgrp)
x_scaled
```

Out[134]:
```
array([[0.57587815, 0.        , 2.38250255, ..., 0.        , 0.
,
        0.        ],
       [3.16732981, 0.        , 3.41024874, ..., 0.        , 0.
,
        0.        ],
       [1.00778676, 0.        , 3.2233858 , ..., 0.        , 0.
,
        0.        ],
       ...,
       [1.00778676, 0.        , 3.12995433, ..., 0.        , 0.
,
        0.        ],
       [0.71984768, 0.        , 2.28907107, ..., 0.        , 0.
,
        0.        ],
       [0.86381722, 0.        , 3.2233858 , ..., 0.        , 0.
,
        0.        ]])
```

In [135]:
```
clustering = KMeans(n_clusters = 5, init = 'k-means++', n_init = 10,rand
om_state=0).fit(x_scaled)
clusters = clustering.labels_
```

In [136]:
```
clusters[0:5]
```

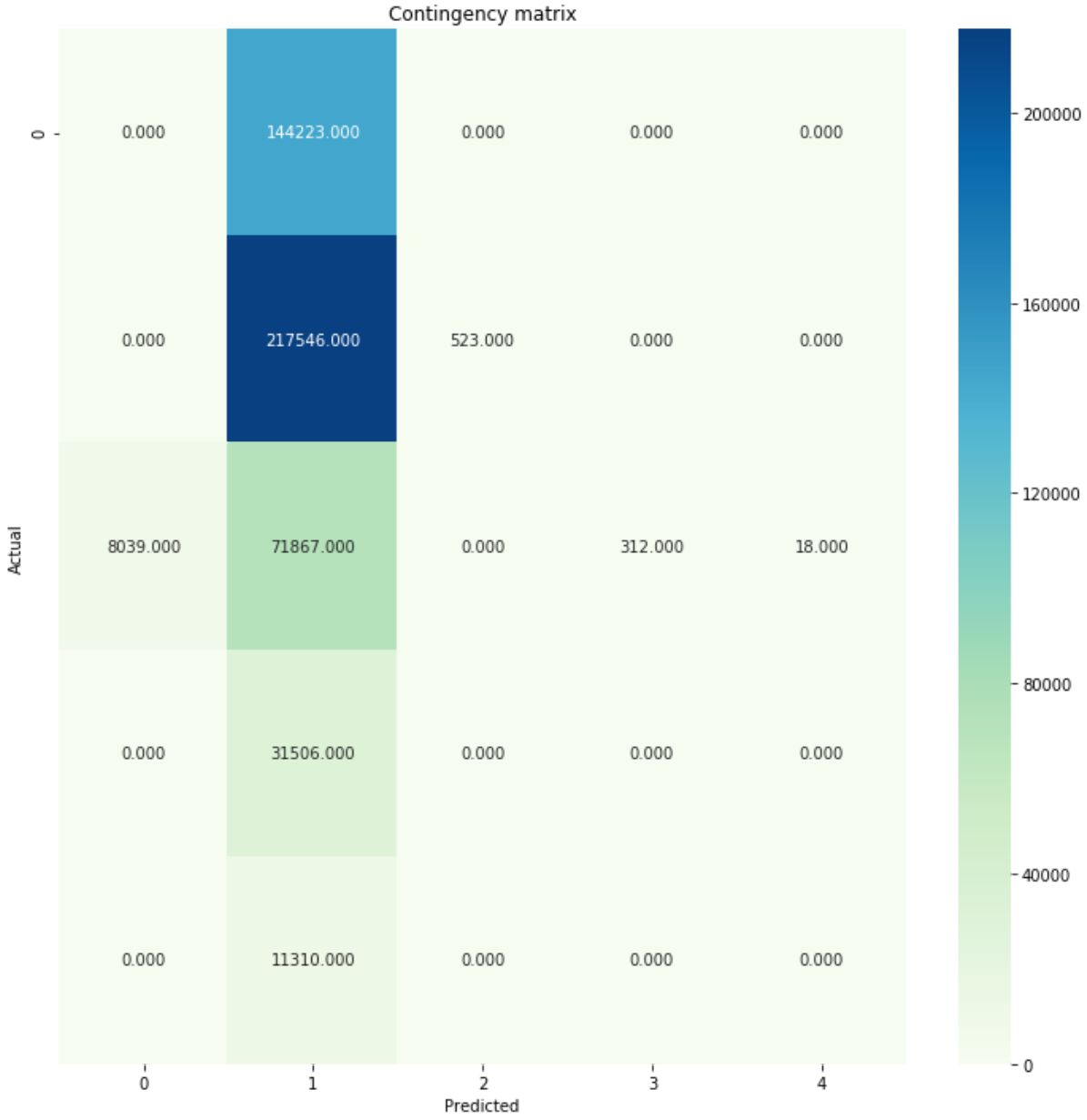
Out[136]:
```
array([1, 1, 1, 1, 1], dtype=int32)
```

In [137]:
```
X_cgrp['clusters'] = clusters
```

In [138]:
```
X_cgrp['clusters'][0:5]
```

Out[138]:
```
0    1
1    1
2    1
3    1
4    1
Name: clusters, dtype: int32
```

In [139]:
```
cont_matrix = metrics.cluster.contingency_matrix(y_cgrp['crimeGroups'],X
_cgrp['clusters'])
fig, ax = plt.subplots(figsize=(10,10))
ax=sns.heatmap(cont_matrix,yticklabels=5, annot = True, fmt = ".3f", squ
are = False, cmap = plt.cm.GnBu)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Contingency matrix')
plt.tight_layout()
```



In [140]:
```
adjusted_rand_index = metrics.adjusted_rand_score(y_cgrp['crimeGroups'],
X_cgrp['clusters'])
silhouette_coefficient = metrics.silhouette_score(x_scaled, clusters, me
tric = "euclidean")
print([adjusted_rand_index, silhouette_coefficient])
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-140-9f851dd1af52> in <module>
      1 adjusted_rand_index = metrics.adjusted_rand_score(y_cgrp['crimeGroups'], X_cgrp['clusters'])
----> 2 silhouette_coefficient = metrics.silhouette_score(x_scaled, clusters, metric = "euclidean")
      3 print([adjusted_rand_index, silhouette_coefficient])

/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/cluster/unsupervised.py in silhouette_score(X, labels, metric, sample_size, random_state, **kwds)
    115         else:
    116             X, labels = X[indices], labels[indices]
--> 117     return np.mean(silhouette_samples(X, labels, metric=metric, **kwds))
    118
    119

/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/cluster/unsupervised.py in silhouette_samples(X, labels, metric, **kwds)
    221                                         labels=labels, label_freqs=label_freqs)
    222     results = zip(*pairwise_distances_chunked(X, reduce_func=reduce_func,
--> 223                                               **kwds))
    224     intra_clust_dists, inter_clust_dists = results
    225     intra_clust_dists = np.concatenate(intra_clust_dists)

/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/pairwise.py in pairwise_distances_chunked(X, Y, reduce_func, metric, n_jobs, working_memory, **kwds)
   1446             X_chunk = X[sl]
   1447         D_chunk = pairwise_distances(X_chunk, Y, metric=metric,
-> 1448                                      n_jobs=n_jobs, **kwds)
   1449         if ((X is Y or Y is None)
   1450                 and PAIRWISE_DISTANCE_FUNCTIONS.get(metric, None)

/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/pairwise.py in pairwise_distances(X, Y, metric, n_jobs, **kwds)
   1586         func = partial(distance.cdist, metric=metric, **kwds)
   1587
-> 1588     return _parallel_pairwise(X, Y, func, n_jobs, **kwds)
   1589
   1590

/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/pairwise.py in _parallel_pairwise(X, Y, func, n_jobs, **kwds)
   1204
   1205     if effective_n_jobs(n_jobs) == 1:
-> 1206         return func(X, Y, **kwds)
   1207
   1208     # enforce a threading backend to prevent data communication overhead
```

```
/opt/anaconda3/lib/python3.7/site-packages/sklearn/metrics/pairwise.py
 in euclidean_distances(X, Y, Y_norm_squared, squared, X_norm_squared)
    263         YY = None
    264     else:
--> 265         YY = row_norms(Y, squared=True)[np.newaxis, :]
    266
    267     if X.dtype == np.float32:

/opt/anaconda3/lib/python3.7/site-packages/sklearn/utils/extmath.py in
row_norms(X, squared)
     71         norms = csr_row_norms(X)
     72     else:
---> 73         norms = np.einsum('ij,ij->i', X, X)
     74
     75     if not squared:

<__array_function__ internals> in einsum(*args, **kwargs)

/opt/anaconda3/lib/python3.7/site-packages/numpy/core/einsumfunc.py in
einsum(*operands, **kwargs)
   1354     # If no optimization, run pure einsum
   1355     if optimize_arg is False:
-> 1356         return c_einsum(*operands, **kwargs)
   1357
   1358     valid_einsum_kwargs = ['out', 'dtype', 'order', 'casting']

KeyboardInterrupt:
```

In [0]:
```
clustering = KMeans(n_clusters = 5,init = 'random', n_init = 40,random_s
tate=0).fit(x_scaled)
clusters = clustering.labels_
```

In [29]:
```
clusters[0:5]
```

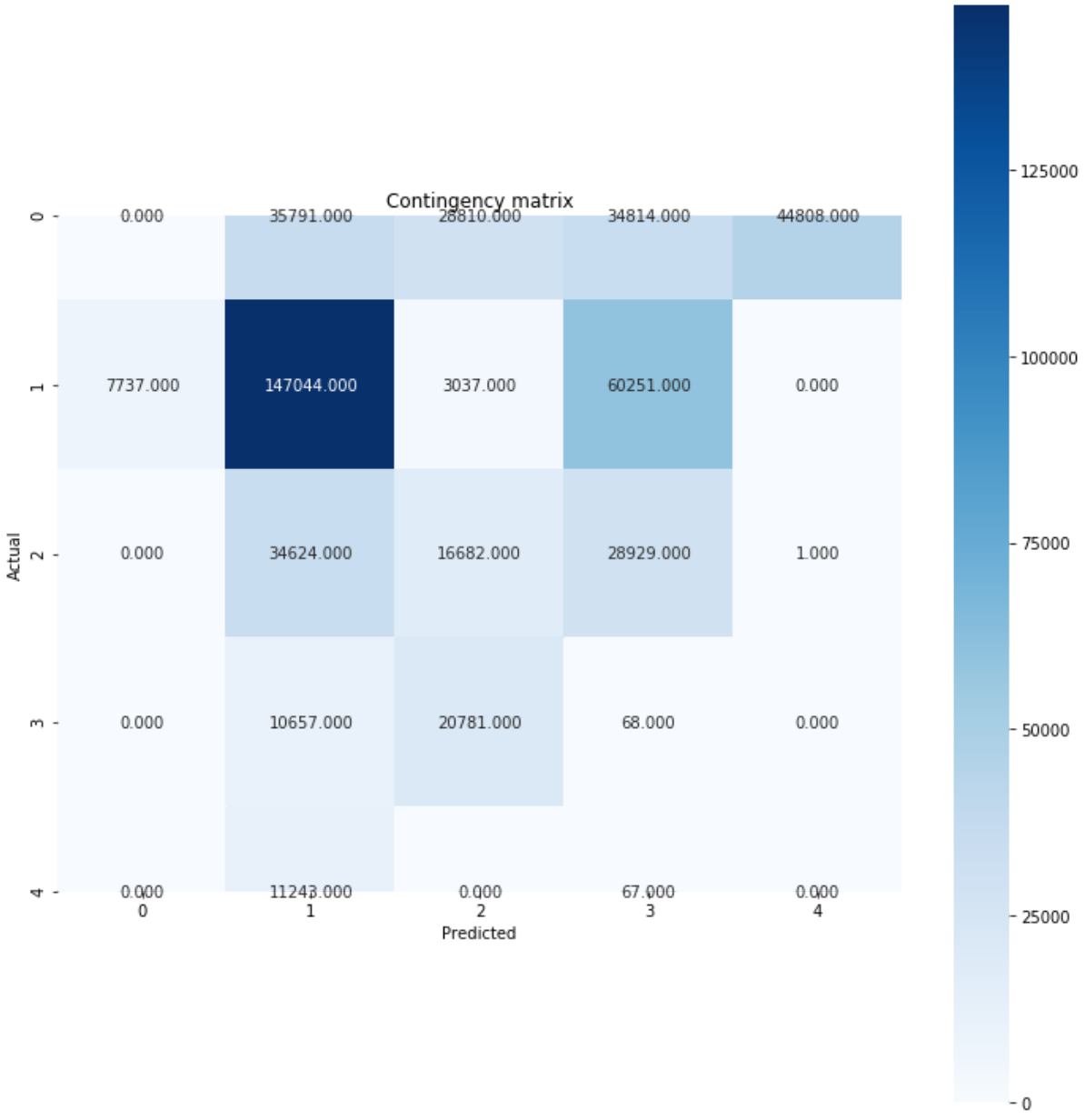
Out[29]:
```
array([1, 1, 1, 3, 2], dtype=int32)
```

In [0]:
```
X_cgrp['clusters'] = clusters
```

In [31]:
```
X_cgrp['clusters'][0:5]
```

Out[31]:
```
0    1
1    1
2    1
3    3
4    2
Name: clusters, dtype: int32
```

In [32]:
```
cont_matrix = metrics.cluster.contingency_matrix(y_cgrp['crimeGroups'],X
_cgrp['clusters'])
fig, ax = plt.subplots(figsize=(10,10))
ax=sns.heatmap(cont_matrix,yticklabels=5, annot = True, fmt = ".3f", squ
are = False, cmap = plt.cm.PuBu)
plt.ylabel('Actual')
plt.xlabel('Predicted')
plt.title('Contingency matrix')
plt.tight_layout()
```



In [33]:
```
adjusted_rand_index = metrics.adjusted_rand_score(y_cgrp['crimeGroups'],
X_cgrp['clusters'])
silhouette_coefficient = metrics.silhouette_score(x_scaled, clusters, me
tric = "euclidean")
print([adjusted_rand_index, silhouette_coefficient])
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-33-9f851dd1af52> in <module>()
      1 adjusted_rand_index = metrics.adjusted_rand_score(y_cgrp['crimeGroups'], X_cgrp['clusters'])
----> 2 silhouette_coefficient = metrics.silhouette_score(x_scaled, clusters, metric = "euclidean")
      3 print([adjusted_rand_index, silhouette_coefficient])

/usr/local/lib/python3.6/dist-packages/sklearn/metrics/cluster/unsupervised.py in silhouette_score(X, labels, metric, sample_size, random_state, **kwds)
    115         else:
    116             X, labels = X[indices], labels[indices]
--> 117     return np.mean(silhouette_samples(X, labels, metric=metric, **kwds))
    118
    119

/usr/local/lib/python3.6/dist-packages/sklearn/metrics/cluster/unsupervised.py in silhouette_samples(X, labels, metric, **kwds)
    221                                         labels=labels, label_freqs=label_freqs)
    222     results = zip(*pairwise_distances_chunked(X, reduce_func=reduce_func,
--> 223                                               **kwds))
    224     intra_clust_dists, inter_clust_dists = results
    225     intra_clust_dists = np.concatenate(intra_clust_dists)

/usr/local/lib/python3.6/dist-packages/sklearn/metrics/pairwise.py in pairwise_distances_chunked(X, Y, reduce_func, metric, n_jobs, working_memory, **kwds)
   1446             X_chunk = X[sl]
   1447         D_chunk = pairwise_distances(X_chunk, Y, metric=metric,
-> 1448                                      n_jobs=n_jobs, **kwds)
   1449         if ((X is Y or Y is None)
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   1586         func = partial(distance.cdist, metric=metric, **kwds)
   1587
-> 1588     return _parallel_pairwise(X, Y, func, n_jobs, **kwds)
   1589
   1590

/usr/local/lib/python3.6/dist-packages/sklearn/metrics/pairwise.py in _parallel_pairwise(X, Y, func, n_jobs, **kwds)
   1204
   1205     if effective_n_jobs(n_jobs) == 1:
-> 1206         return func(X, Y, **kwds)
   1207
   1208     # enforce a threading backend to prevent data communication overhead
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/metrics/pairwise.py in e
uclidean_distances(X, Y, Y_norm_squared, squared, X_norm_squared)
    271     else:
    272         # if dtype is already float64, no need to chunk and upc
ast
--> 273         distances = - 2 * safe_sparse_dot(X, Y.T, dense_output=
True)
    274         distances += XX
    275         distances += YY

/usr/local/lib/python3.6/dist-packages/sklearn/utils/extmath.py in safe
_sparse_dot(a, b, dense_output)
    140         return ret
    141     else:
--> 142         return np.dot(a, b)
    143
    144

<__array_function__ internals> in dot(*args, **kwargs)

KeyboardInterrupt:
```

In [0]:
```
hier = AgglomerativeClustering(n_clusters=5)
y_pred = hier.fit_predict(x_scaled)
```

In [0]:
```

```

In [0]:
```

```